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ABSTRACT

This paper illustrates the themes of reflection and connection in teacher education by discussing the experiences and conceptions of one preservice teacher who was enrolled in a secondary mathematics methods course. Small groups of preservice teachers created hypermedia stacks to demonstrate their views on important issues in mathematics education. Stacks include hypertext links, video-taped segments of practice teaching, other video and audio components, and links to other applications. This paper elaborates on how hypermedia activity enables and encourages preservice teachers to reflect on and develop their beliefs, and to build explicit connections within their experiences in university and field settings. It illustrates the powerful ability of hypermedia activity to not only allow prospective teachers to personalize reform themes, but also provide a context for researchers to question and investigate prospective teachers' beliefs about mathematics teaching and learning. Contains 27 references. (Author)

Hypermedia Creation: Offering Prospective Secondary Teachers Opportunities to Build Flexible and Powerful Conceptions of Mathematics and Mathematics Teaching

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Abstract

This paper illustrates the themes of reflection and connection in teacher education by discussing the experiences and conceptions of one preservice teacher, Alice, who was enrolled in a secondary mathematics methods course. Small groups of preservice teachers create hypermedia stacks to demonstrate their views on important issues in mathematics education. Stacks include hypertext links, video-taped segments of practice teaching, other video and audio components, and links to other applications. The paper elaborates how hypermedia activity enables and encourages preservice teachers to reflect on and develop their beliefs, and to build explicit connections within their experiences in university and field settings. It illustrates the powerful ability of hypermedia activity to not only allow prospective teachers to personalize reform themes, but also to provide a context for researchers to question and investigate prospective teachers' beliefs about mathematics teaching and learning.

Hypermedia Creation: Offering Prospective Secondary Teachers Opportunities to Build Flexible and Powerful Conceptions of Mathematics and Mathematics Teaching

Recent efforts to overhaul the secondary curriculum in the United States have drawn increased attention to themes of inquiry, cooperation, and problem solving in the mathematics classroom (National Council of Teachers of Mathematics [NCTM], 1989). Many prospective teachers possess weak knowledge and narrow views of mathematics and mathematics pedagogy that include conceptions of mathematics as a closed set of procedures, teaching as telling, and learning as the accumulation of information (Ball, 1991; Brown, Cooney, & Jones, 1990; Even, 1993; Thompson, 1992; Wilson, 1994). These conceptions are bolstered by years of experience as students in traditional classrooms (Lortie, 1975). If reform themes are to be enacted in the mathematics classrooms of future teachers, conceptions of mathematics and teaching need to challenged and developed in ways that will support meaningful and lasting change (Knapp & Peterson, 1995; Prawat, 1992; Richardson, 1990; Smith, 1996).

In light of the differences in the instructional methods prospective teachers will be expected to use in schools and those they likely experienced as students of mathematics, teacher education programs face significant challenges. They are faced with the task of creating opportunities for prospective teachers to critically consider important teaching and learning ideas so that more flexible conceptions of mathematics and teaching may develop. Two important themes emerge as teacher educators consider ways to enhance the experiences of prospective teachers: reflection and connection. These themes are discussed in the following section and are used to help interpret the experiences and statements of one prospective teacher during a hypermedia creation activity in a secondary mathematics methods class.

Reflection and Connection in Teacher Development

For prospective teachers to embrace reform-oriented views and practices, they need to participate actively and self-consciously in the process of developing and refining their personal conceptions of mathematics pedagogy. Much of the literature on teaching in general, as well as on

mathematics teaching in particular, stresses the importance of encouraging teachers to become *reflective practitioners* (Roth, 1989; Schon, 1983; Valli, 1992; Zeichner & Liston, 1987). Being a reflective practitioner involves not only spontaneous and immediate reflection on the teaching task, but also thinking seriously about teaching experiences from a distance. Such creative and critical reflection about beliefs and practice can powerfully impact a teacher's relationship to his or her role in mathematics teaching and learning. Ongoing reflective action can greatly enhance teachers' development of theories of practice (Smyth, 1989). Habits of reflection are necessary if prospective teachers are to see themselves as decision-makers who will engage in career-long learning about students, mathematics, and pedagogy.

To effectively promote professional development, reflection-oriented activities should carefully take into account the conceptions, current practices, and needs of the particular teacher (Lasley, 1992). Beginning teachers, who often lack confidence in their abilities to develop and maintain effective classroom practices and who may not fully appreciate the complexities of mathematics pedagogy, may particularly benefit from reflection on and focused analysis of very specific issues, concepts, or practices. Such focused activity allows prospective teachers to transform tacit or unexamined beliefs into more explicit views which they can draw on and adjust as they enter the mathematics classroom (Fenstermacher, 1979).

One of the most important aims of incorporating critical reflection into teacher education courses and programs is to promote teachers' building of several different types of connections within their beliefs and experiences. Prospective teachers need to make connections between their views of mathematics pedagogy, which largely grow out of their own experiences as students of mathematics, and the more formally articulated theories of content, teaching, and learning that form the core of the methods course activities. For example, many prospective teachers' views of what it means to teach are compilations of positive and negative images of prior teachers (Knowles, 1992). By connecting a past experience with a new pedagogical conception, reflection in a teacher education context may guide the reinterpretation of such images into more realistic and useful models of teaching.

Prospective teachers also need to make connections among theories and issues of content, teaching, and learning. For example, a teacher begins to translate the knowledge developed as a student of mathematics into pedagogical content knowledge (Shulman, 1987) as he or she revisits content from new perspectives based on theories of student learning and methods of instruction. Facilitating this complicated type of connection, and the resulting development of new conceptions, necessitates extensive reflection and analysis on the part of the prospective teacher.

Another important connection that can be encouraged by reflection is between different aspects of the learning-to-teach experience. Prospective teachers frequently do not interpret their classroom experiences in ways that are consistent with the theory emphasized in teacher education courses. Rarely do the worlds of theory and practice meet-- the university supervisor is typically the only person (other than the prospective teacher) to participate in both experiences. As a result, prospective teachers may view their teacher education programs as a series of disjointed experiences lacking a common theme or goal:

> Most preservice teachers are unable to grasp the whole while experiencing the myriad of disconnected parts of the curriculum. Many teacher education programs fail to challenge their students to understand how ideas are connected and/or related to field experiences. (McIntyre, Byrd, & Foxx, 1996, pp. 171-172)

As prospective teachers attempt to make sense of their practice or student teaching experiences, it is of utmost importance that they receive support in using their university knowledge to do so. Conversely, field experiences provide a context for prospective teachers to deepen and receive validation about theories discussed in methods courses. Reflection on experiences in field and university settings enables prospective teachers to develop conceptions that incorporate diverse ideas and examples and thus include richer, more useful information that will better support their learning-to-teach.

Hypermedia Technology in Teacher Education

Motivated by efforts to provide prospective teachers with opportunities for significant reflection and connection, teacher educators have turned increasingly to computer technology in

recent years. Because they enhance teacher development in ways that may not be possible using other instructional tools, hypermedia applications in particular have grown in popularity among teacher educators. The most common instructional use of hypermedia involves prospective teachers working in pre-designed computer environments to explore and respond to various teaching events and issues (e.g., Daniel, 1996; Hatfield, 1996).

In contrast, the program discussed in this paper involves *hypermedia creation* by the prospective teachers themselves. Prospective teachers enrolled in a secondary mathematics methods course develop hypermedia stacks to communicate their understandings of important issues in mathematics teaching and learning. Student-created hypermedia stacks include links to documents in other applications (such as text files, mathematics software, or world-wide web pages) and also incorporate quick-time movies of video-taped segments from practice teaching. These hypermedia activities assist prospective teachers in reflecting upon and building explicit links within their own experiences. This paper illustrates how prospective teachers' conceptions of mathematics and mathematics teaching are developed, refined, and reflected upon during hypermedia project creation.

The Hypermedia Program and Sample Project

Prospective secondary mathematics teachers at a large midwestern university were studied while they participated in a mathematics methods course. The methods course is typically completed by seniors during the semester before student teaching. During this study, methods students were also enrolled in a 2-part pre-student-teaching practicum. Immediately after the methods class meetings (two days per week) prospective teachers tutored students from nearby high and middle schools and they assisted (in pairs) on 2 days per week in nearby schools. One placement (7 weeks) was in a high school course using reform-oriented curriculum materials developed by the Core-Plus Mathematics Project (Hirsch, Coxford, Fey, & Schoen, 1995). Teachers also spent 7 weeks at a middle school, assisting in classes that incorporated computer demonstrations and other alternative assessment techniques. It is from these practice teaching settings that prospective teachers obtained video segments and other items (e.g., sample activities)

for their hypermedia projects. Interns also construct individual hypermedia portfolios during their subsequent student teaching experience (Wilson & Lloyd, 1997).

During the fall semesters of 1995 and 1996, methods students created hypermedia projects representing their views about various topics, including mathematics anxiety, cooperative learning, alternative assessment, technology, diversity, equity, state-wide competency testing, mathematical communication, real-world applications, and multiple learning styles. To exemplify what the hypermedia stacks looked like and to provide a context for understanding the discussion in the next section, we briefly describe one of the projects.

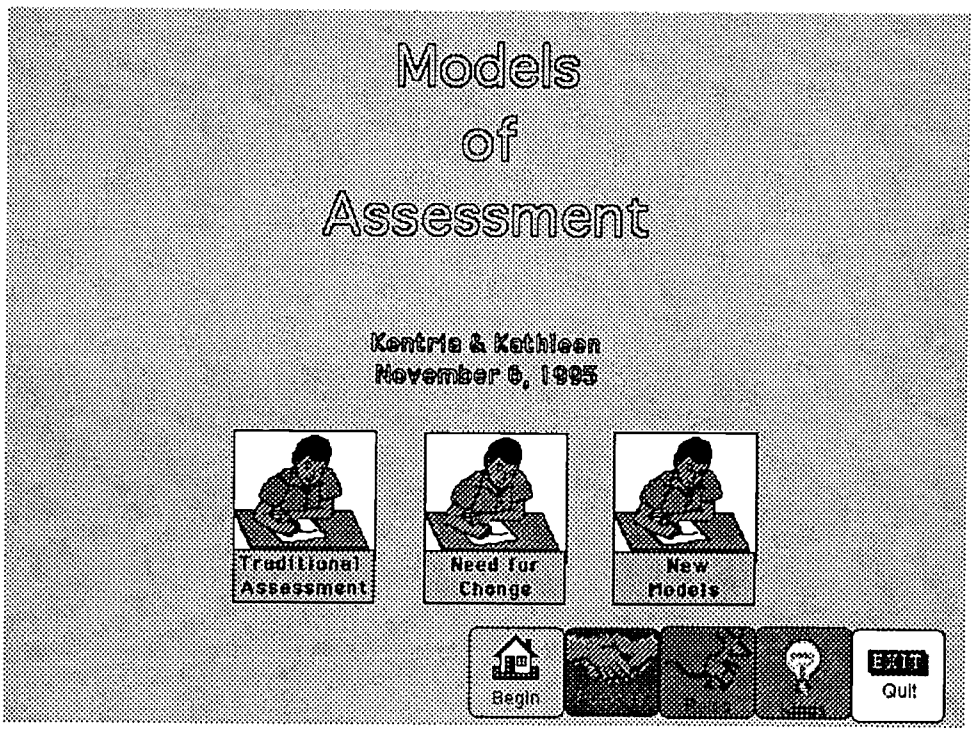

Figure 1. Early card in the "Models of Assessment" project

The card in Figure 1 shows the organization of a hypermedia project about alternative assessment. To introduce the topic, the prospective teachers constructed a card displaying several examples of traditional test items and quick-time movies of high school students sitting at their desks quietly taking mathematics tests. After being introduced to the idea of and need for alternative assessment, the user can move to cards providing him or her with options to explore "Purposes" of alternative assessment activities, teacher "Roles" in alternative assessment

environments, and "Kinds" of alternative assessment activities. In the "Kinds" branch of the stack, the examples of alternative assessment activities include one that takes the user to *Geometer's Sketchpad* (mathematics software) documents. The card shown in Figure 2 illustrates the organization of the "Roles" branch. The *hypertext* words "Observe," "Record," and "Communicate" allow the user, by clicking on the appropriate word, to follow the associated sub-path. One card in the "Observe" sub-branch contains a quick-time movie (and related text describing the situation) of one prospective teacher observing and interacting with high school students during her practice teaching.

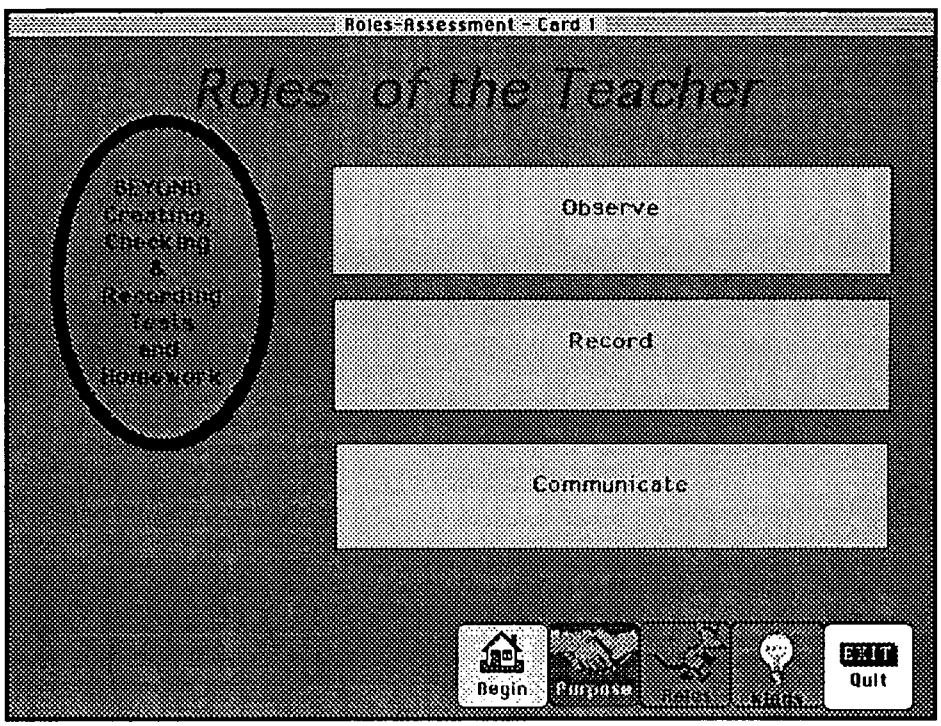

Figure 2. First card in the "Roles" branch of the "Models of Assessment" stack

As this sample project suggests, hypermedia technology offers a powerful tool for encouraging prospective teachers to combine various media and aspects of their experiences as they represent their views about important issues in mathematics education. The main themes of reflection and connection that guided our development of the hypermedia program are further illustrated in the following description of one prospective teacher's experience with the activity during her methods course and associated pre-student teaching.

The Case of Alice

To illustrate how teachers' conceptions of mathematics and mathematics teaching are reflected upon and refined during hypermedia creation, we focus on the project and experiences of one prospective teacher, Alice. These findings also provide information about the types of connections teachers have opportunities to make as they engage in hypermedia activity.

This description of Alice is based on our analysis of her hypermedia project, her presentation based on this project, her responses to a written questionnaire, and transcripts of 2 one-hour interviews. One of the interviews allowed Alice to elaborate her responses to a written questionnaire asking her (and the other participants in the course) to comment on her conceptions of mathematics and mathematics teaching. This interview, completed during the first week of the methods course, not only provided useful background information, but illustrates how many of Alice's ideas about mathematics and mathematics teaching were incorporated into her hypermedia project. The other interview focused specifically on the hypermedia project. During this interview, Alice was encouraged to comment about how the experience of creating the hypermedia project impacted her understanding of her chosen theme, and mathematics and mathematics teaching more generally.

At the beginning of the methods course Alice described deciding to become a teacher because she enjoyed working with children, and particularly enjoyed studying their learning and development. She chose to teach mathematics not only because she liked the subject and was good at it, but because mathematics "applies to everything in the world." Although the fact that mathematics is everywhere "is not something that we are taught," she believes strongly that emphasizing real-world applications will help students connect school mathematics with everyday mathematics:

> When people say that they don't like math or that they can't do math, they are thinking of *school* math and they don't realize how much math they do every day that they don't even think about. . . . If they realized how much they were actually

> doing, then they wouldn't say that they hate math or that they can't do it, because they are doing it.

In her view, "everyday math" and "school math" should be presented together. For example, she explained that students should be given opportunities to relate mathematical concepts to everyday activities such as figuring out restaurant tips, or prices of items that are on sale. She pointed out that even though "any teenager can say what 20% off their shirt is going to be," most students do not apply the same understanding when required to do a worksheet of 25 exercises involving percents.

Alice's comments about the prevalence of mathematics in everyday life are consistent with her group's choice of topic for the hypermedia project, "Bringing Real-World Applications into the Classroom."

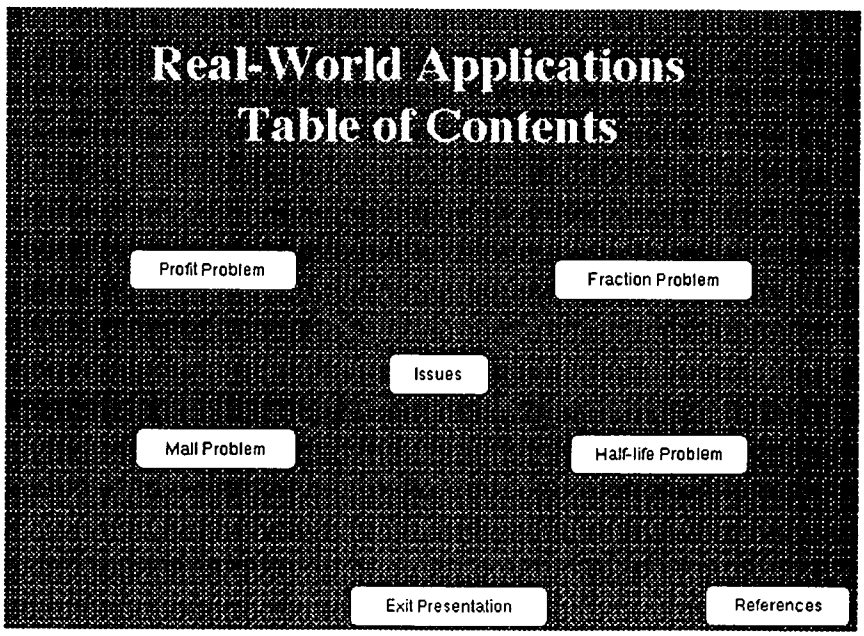

Figure 3. Table of Contents of Alice's Project

The table of contents, shown in Figure 3, shows how the project was structured around various real-world problems and activities that can be used in middle and high school mathematics classes. Alice described the group's work in constructing and organizing the project,

> For each problem, we presented either our solution or some of the students' solutions. Then-- we all did it a little differently-- but I went through and talked about why I thought

it was a good problem and for what age group. . . . Then [we] went through each Standard that we picked out and described a little bit about how applications could meet that Standard.

As her comment indicates, the project discusses how the four problems and the idea of applications in general support many recommendations of the NCTM *Standards*. The specific Standards that the group chose to discuss are outlined in Figure 4.

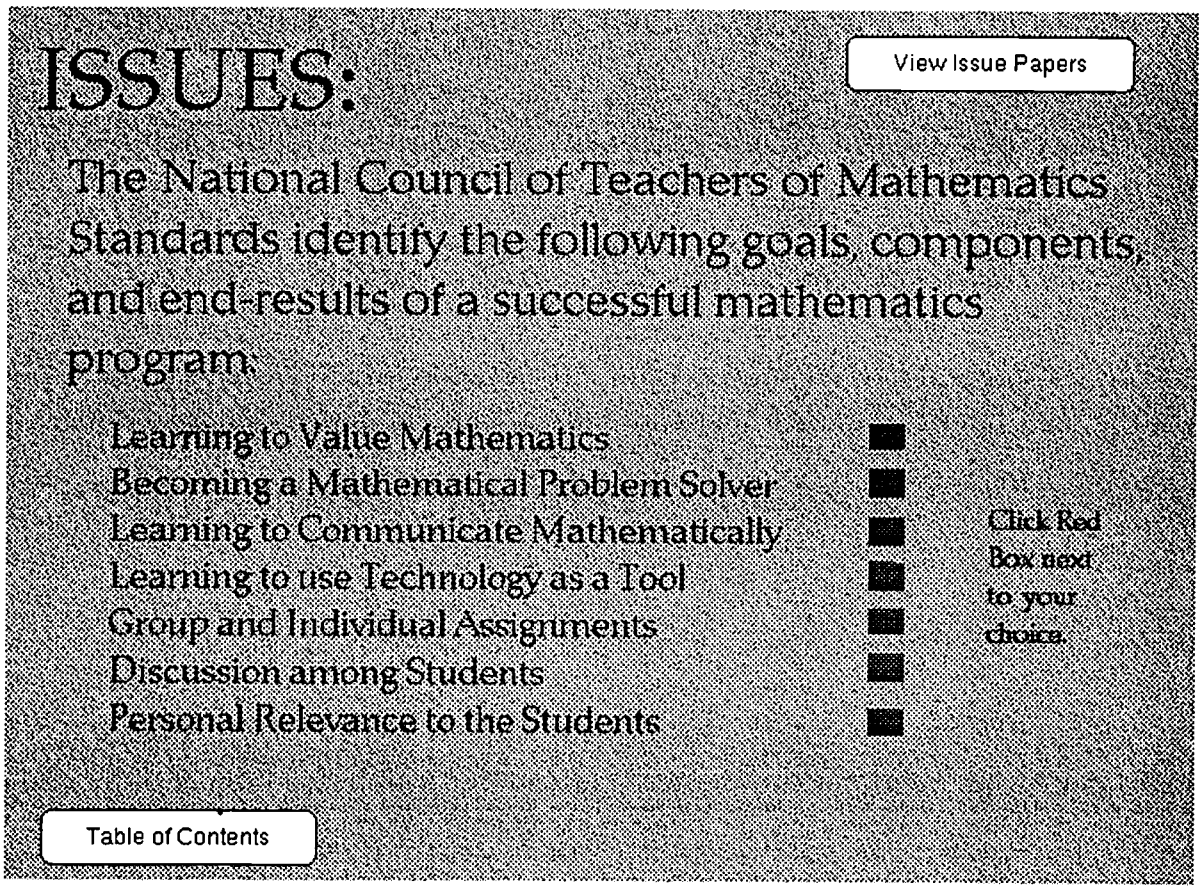

Figure 4. Card Summarizing how Real-World Applications Support the Standards

The group's elaboration of the "Learning to Value Mathematics" Standard coincided very closely with statements Alice had made in her initial interview. The elaboration card stated,

> The NCTM Standards stress that students recognize the existence of mathematics in our society. The use of real-world applications will present the students with concrete examples of mathematical situations that can be observed in everyday life.

When students see that math DOES exist outside of the classroom, they will develop a greater VALUE for mathematics in general.

That this project was a cooperative group effort of three students (including Alice), but strongly relates to similar comments made by Alice at the beginning of the methods course, suggests the strength of her views and their role in influencing her group's decisions about the project themes.

One of the problems developed and described in the project was based on an activity used in the middle school class where Alice assisted as a pre-student teacher. The problem is stated below and in Figure 5:

When Tupolo Township was founded, the land was divided into sections that could be farmed. Each section is a square that is 1 mile long on each edge--that is, each section is 1 square mile of land. There are 640 acres of land in a 1-square-mile section.

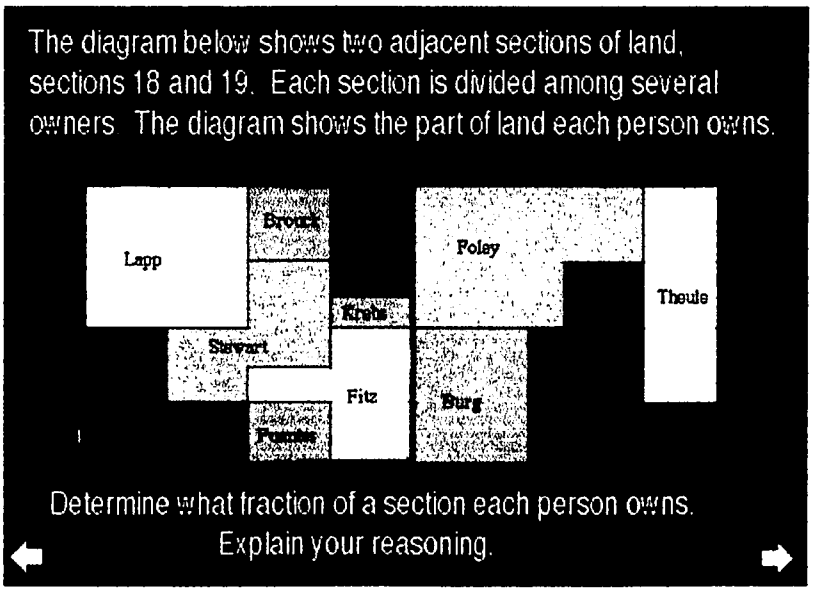

Figure 5. Diagram of Fraction Problem from Alice's Project

In talking about this problem during our discussion of her project, Alice reflected on her experience in the classroom where this problem situation was explored:

It was a really involved problem. I liked the way that the teacher set it up. She was talking about how she grew up on a farm and was relating it to how her father had to buy all his land and decide how much he wanted to plant and how much more land he was going to

> need. She set it up saying that it is something that really happens every day with farmers and the kids were really interested in it. Watching them work in groups and stuff you could see that everyone was involved and was talking about the problem and even if they didn't understand the answer they had the words to ask their questions because they could talk in English about a problem that they could picture. So then I heard them talking in English about adding and subtracting fractions and then figuring out that this is what they are supposed to be doing.

The above quote alludes to many of the potential benefits for students of real-world problems that Alice mentioned in her first interview. However the above comments advance her previous ones by including the classroom context: Reflecting on her practice teaching, she was able to articulate a specific example of how a teacher structured an exploration of this real-world problem and how students responded to the situation. This problem in the hypermedia project represents an explicit link, between Alice's conceptions and classroom experiences, that provides a richer perspective from which she can view and appreciate the role of real-world applications in mathematics teaching.

This comment also indicates the role perceived by Alice of how real-world problems can set the context for the type of mathematical activity that includes extensive exploration, communication, and "sense-making" by students. Through participation in her pre-student teaching placement, observations of other classes using application problems (e.g., Core-Plus high school classes), and her tutoring work, Alice developed an appreciation for having students "really talking in class and talking about math." The Fraction Problem in the hypermedia project incorporates not only a meaningful real-world context, but also the extensive student cooperation that she observed and participated in during her field experiences. A related issue identified by Alice was how to determine whether mathematical ideas and solutions "make sense" given a particular situation or real-world context. That this issue was on her mind as she constructed the hypermedia project is evidenced by her explanation of why she had decided to include a particular

quick-time movie from a video segment (showing her leading a discussion about solving one of the project's problems):

> I chose that clip because of the discussion about how we knew whether that answer made sense or not. . . . I included it because I thought it really showed the discussion of the problem and figuring out how to find out if our answer was right or not.

The importance to Alice of students making sense of solutions and communicating their thoughts was deepened by her interactions with the other group members regarding the problems incorporated in the hypermedia project:

> [In the hypermedia project] we talked about assessment a little bit, that if you can solve the problem, it doesn't really mean that you know what is going on. Usually the real world problems are set up so that you *have* to write about your answer and explain your thinking. We thought that was a stronger part of the problems [included in our project] because we really got to know what was going on. One student in the class--we used her sample of work [in our hypermedia project]--she had a column of the answers that she came up with and then a column labeled "How I know." She reasoned through everything that she did.

As this comment suggests, project creation enabled Alice and her peers to discuss important issues such as assessment and problem solving, and share in each other's ideas. It also required them to determine how to incorporate specific examples of student work into their project.

There was considerable value in having Alice, during her pre-student teaching practicum, assist in classes and individually tutoring students from classes where her project theme and other reform themes (e.g., cooperative learning) were effectively enacted. Observing and participating in innovative activities is extremely important in learning to teach in innovative ways. But by creating the hypermedia project, Alice was able to even more deeply connect these experiences with her own conceptions. Alice's comments reveal how her beliefs about mathematics and mathematics teaching, that real-world examples help students to value and understand mathematics, and her more recent middle and high school classroom experiences influenced the construction of many aspects of her hypermedia project.

Discussion

At the beginning of the mathematics methods course, Alice had begun to translate some of her prior experiences as a mathematics student into pedagogical content knowledge (Shulman, 1987). She recognized that most of the mathematics she had learned about was not connected to the real world. Because project creation allowed her to revisit this experience from a perspective based on theories of teaching and learning, Alice not only received validation about the significance of this experience, she was able to reflect on its significance and connect it to her growing conceptions of mathematics teaching.

Effective teacher preparation allows teachers to articulate (and build upon) their beliefs about teaching, learning, and mathematics (Liston & Zeichner, 1988). Alice used the hypermedia project to do this. The project enabled her to take into account her existing conceptions and needs. Additionally, it provided her with opportunities to focus on a very specific issue--real-world applications. Such specific focus enabled Alice and the other prospective teachers to consider, represent, and perhaps transform their beliefs, which were probably held tacitly up to the point of teacher education activity (Fenstermacher, 1979), so that they could be accessed and used explicitly in future classroom teaching.

Our paper contains numerous other examples of meaningful reflection and consequent connection. In the assessment stack (used to introduce the hypermedia program), the video segment showing one of the teachers "catching [her students] being right" demonstrates that the preservice teachers who created the project had reflected on the existence, meaning, and importance of this teacher role. That some cards in this assessment stack are accessible from various points, also illustrates the interconnections in how the teachers viewed various alternative assessment themes. For example, because it contains both written and oral components, one suggested "project" can be reached through two different sub-branches of the stack. Another evidence of connection in the assessment stack is the existence and use of links to other applications (e.g., *Geometer's Sketchpad).*

As this paper demonstrates, the pedagogical benefits of the hypermedia program are numerous. Hypermedia activity *requires* prospective teachers to reflect on and build explicit connections between their field experiences and their developing understandings of mathematics and mathematics teaching. Because video segments of practice teaching, for example, are explicitly linked to textual or other representations of the chosen themes, hypermedia environments allow prospective mathematics teachers to place together in a single document multiple representations of the learning-to-teach process. The teachers recognize the hypermedia format's powerful ability to represent their themes coherently. In Alice's words,

> You could have shown the same information in another way but you would be giving a speech having either overheads or would be writing on the board. You would have to bring in a TV and a VCR to show the clips. It really made an efficient way of bringing it all together.

Although teachers can view video segments and think about their teaching without hypermedia technology, physically connecting several representations of the learning-to-teach process increases the likelihood that prospective teachers will develop integrated understandings of what it means to teach mathematics.

We are also encouraged by the hypermedia program's potential to assist us in conducting research. Prospective teachers generally possess meaningful and powerful beliefs, but it is sometimes difficult to establish a context that will encourage them to reveal their beliefs (e.g., Cooney, 1985). The projects discussed in this paper provide such a context. For example, which video segments prospective teachers choose for their projects and why they choose them can be very revealing about what they think it means to teach mathematics. The fact that Alice's project was so closely aligned with her existing beliefs about mathematics and mathematics teaching illustrates very clearly that projects can serve as excellent contexts for discussions with prospective teachers about their beliefs. Her project and comments about it gave us an additional way to probe and analyze her views.

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